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ABSTRACT

This research project was designed to explore ways of making computer text presentations more readable as a way of compensating for the constraints that computers impose on the display of text as compared with print-on-paper displays, e.g., limited screen resolution and display area. Forty-eight undergraduate teacher education majors enrolled in an instructional technology course received either a print or computer-based instruction (CBI) statistics lesson containing low-density (concise) narrative text, high-density (conventional) text, or the density type they preferred (learner-control). Results showed that the low-density display reduced completion time relative to the high-density version, while yielding equivalent achievement. Subjects receiving the lesson in the print mode had shorter completion times and higher achievement than their CBI counterparts. Attitude results showed that CBI was favorably regarded, but perceived as longer and slower-moving than print. A discussion of these results and their implications for designing instructional material in accord with CBI attributes and learner characteristics concludes the report. A 52-item list of references is provided, as well as three tables and samples of low-density and high-density frames from the CBI lesson. (Author/MES)

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The Influences of Varying Text Densities in Teaching with Computer and Print Presentations

by

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Abstract

Presenting narrative text in computer-based instruction (CBI) is more difficult than in print lessons due to limited screen resolution and display area. The main interest of the present research was achieving a more compatible match between lesson content and the attributes of the presentation media employed. College students received either a print or CBI statistics lesson containing low-density (concise) narrative text, high-density (conventional) text, or the density type they preferred (learner-control). Results showed the low-density lesson to reduce completion time relative to the high-density version, while yielding equivalent achievement. Subjects receiving the lesson in the print mode had shorter completion times and higher achievement than their CBI counterparts. Attitude results showed that CBI was favorably regarded, but perceived as longer and slower-moving than print. Implications of results for designing instructional material in accord with CBI attributes and learner characteristics are discussed.

Text Density Level as a Design Variable in Instructional Displays

The relative effectiveness of computer-based instruction (CBI) compared to traditional methods remains an unresolved issue (Clark, 1985; Petkovich & Tennyson, 1984). Clark (1983; 1984; 1985) argues, for example, that the learning benefits attributed to CBI are readily available from other media. Where research results have favored CBI (as in Kulik, Kulik, & Bangert-Drowns, 1984), the effects may be mostly due to the absence of proper controls over content and methods (Clark, 1985). Others, however, take the view that CBI can significantly enhance learning when designed to capitalize on special qualities of computer delivery that would be impossible or difficult to duplicate with other media (Anand & Ross, in press; Petkovich & Tennyson, 1984). Unfortunately, instructional designers frequently ignore those capabilities by creating CBI lessons using the same design formats and teaching strategies traditionally incorporated in print lessons (Bork, 1985; Burke, 1981).

The rationale for the present research was based, in part, on consideration of constraints that computers impose on the display of text relative to print-on-paper displays (Feibel, 1984; Grabinger, 1983; Lancaster & Warner, 1985; Richardson, 1980). Specifically, computer text offers considerably less flexibility than books by: (a) limiting the visible display to one page at a time, (b) making backward paging for review purposes more difficult, (c) limiting the size of the page layout to about 24 lines and 40-80 characters (Grabinger, 1983), and (d) offering limited cues regarding lesson length. In view of these factors as well as CBI's growing influence in virturally every school subject, exploring ways of making computer text presentations more readable seems both practically and theoretically important.

There is consensus among instructional designers that screen formats should minimize clutter and maximize "white space" in the display area (Allessi & Trollip, 1985; Bork, 1985; Burke, 1982; Caldwell, 1980; Heines, 1984). College students surveyed by Grabinger (1983) corroborated this view by expressing preferences for double-spacing over single-spacing, and increased space in indenting paragraphs. One popular system for spacing text is "chunking" (Bassett, 1985; Grabinger, 1983), which involves separating sentences into meaningful thought units with blank spaces surrounding each. Chunking and similar methods, however, have failed to show clear advantages under either print or CBI presentations (cf, Bassett, 1985; Carver, 1970; Feibel, 1984; Gerrell & Mason, 1983; O'Shea & Sindelar, 1983). A possible limitation is that they leave lesson content unaltered while presenting it in an unfamiliar format.

The main interest in the present research was varying lesson content in accord with attributes of the presentation media employed. Of specific concern was the level of "richness" or detail provided in narrative text, an attribute we will label text "density level." In earlier research with print material, Reder and Anderson (1980; 1982) compared complete chapters from college textbooks with summaries of main points on both direct and indirect questions. In 10 separate studies, summaries were found to be comparable or superior for learning to the original text. The authors concluded that summaries may help students to isolate central ideas without the distraction of having to attend to unimportant details. Similar to the Reder and Anderson (1980) study, the present conception of text density level concerned such attributes as length of materials (number of words used), redundancy of explanations, and depth of contextual support for important concepts. This construct resembles what reading researchers have labeled the "microstructure" of text (Davison & Kantor, 1982), as contrasted with

"macrostructure" which concerns how information is organized and elaborated through comparison of examples, nonexamples, and concept categories (Di Vesta & Finke, 1985; Frayer, Fredrich, & Klausmier, 1969; Moes et al., 1984; Reder, Charney, & Morgan, 1986). Consider, for illustrative purposes, the following two descriptions of the median taken from two introductory statistics texts.

1. The second-most used measure of central tendency is the median; its definition is straightforward. The median was introduced several times in Chapter 3, as in the median family income and median (P_{50}) IQ. The median is the 50th percentile of a distribution - the point below which half of the observations fall. In any distribution, there will always be an equal number of cases above and below the median. The interpretation of the median is even more direct and clear-cut than that of the mean (Hopkins & Glass, 1978, p. 53).
2. The median (Mdn) is the exact middle point in a frequency distribution. It is defined as the scale point that divides a distribution of scores exactly in half. The median is equal to the 50th percentile point, P_{50}. The simplest approach to finding the median is to cast the scores into a frequency table, then compute P_{50} using the following formula (formula follows):... (Glasnapp & Poggio, 1985, p. 91).

Both definitions are clearly written and representative of styles typically found in college-level textbooks. Further, both consume relatively little space on a standard textbook page. Selection 1, for instance, consumes approximately 1 in. of vertical space and 13% of the total page area, whereas selection 2 consumes .75 in. of vertical space and 9% of the page area. By comparison, were the same selections to be presented by CBI, they would respectively require approximately 70% and 50% of a 40-column screen area when single-spaced.

Now examine the following "low-density" version of each segment:

1.b. The median: 2nd most popular central tendency measure. Chapter 3 examples: median family income and median (P_{50}) IQ. Is 50th percentile of any distribution: 1/2 the scores below it; 1/2 above. Easier to interpret than mean.

2.b. The median (Mdn) is exact middle point in frequency distribution. Divides distribution in half. Equals 50th percentile point, P_{50}. Calculate by frequency table and using the following:....

Both low-density versions contain the same information as the originals, but eliminate details and nonessential words. The result is approximately a 50% reduction in both number of words and screen area required. One hypothesis in the present study was that such low-density narrative would promote better learning and more favorable attitudes on CBI lessons by reducing reading and cognitive processing demands of screen displays.

A second research interest was the nature and effects of learner preferences for different density levels in print and CBI modes. Although "learner-control" strategies that allow students to self-determine instructional conditions have shown positive results in some studies (Judd, Bunderson, & Bessent, 1970), recent findings have more often been negative (Carrier, Davidson, & Williams, 1985; Carrier & Sales, 1985; Fisher, Blackwell, Garcia, & Greene, 1975; Lahey & Crawford, 1976; Ross & Rakow, 1981; Tennyson, 1980). Studies of aptitude-treatment interaction (ATI) effects further suggest that the less the student's prior knowledge, the less effective learner-control tends to be (Carrier & Sales, 1985; Fisher et al., 1975; Gay, 1986; Hannafin, 1984; Ross & Rakow, 1981; 1982; Tennyson, 1980). Accordingly, we hypothesized that learner selection of density level would not be advantageous on the present task which

involved learning unfamiliar material in introductory statistics. It was further expected that low-density material would be a more popular choice than high-density material under CBI due to the relative difficulty of reading text from CRT screens. To examine these questions, the present research design consisted of crossing two presentation modes (computer vs. print) with three text density conditions (high, low, and learner control). Dependent variables were different types of learning achievement, lesson completion time, attitudes, and learning efficiency.

Method

Subjects and Design

Subjects consisted of 48 undergraduate teacher education majors enrolled in an instructional technology course. Participation was voluntary and was compensated by points credited to students' course grades. Subjects were assigned at random to six treatment groups in which learning materials were presented in either of two modes (computer or print) under one of three text density-level conditions (high, low, learner control). At the completion of the task they were administered an attitude survey and an achievement posttest designed to measure knowledge, numerical problem-solving, and transfer learning.

Materials

Materials used in the study are described below in the order in which they were administered to subjects.

Profile data form. A brief questionnaire containing three items was used to determine subjects' attitudes toward mathematics and CBI. Ratings were recorded on five-point Likert-type scales, with "5" representing the most positive reaction. The first item concerned the desirability of math-related subjects, the second how the respondent generally performed in such subjects, and the third

whether learning math from a computer would be preferable to learning it from a textbook.

Instructional Unit

The instructional material was an introductory unit on central tendency. Content was adapted from self-instructional learning modules developed by Ross (1983) for use in an undergraduate statistics course taught by the Personalized System of Instruction method (Keller, 1969). For present purposes, the unit was organized into five sections covering the mean, the median, the mode, uses of central tendency measures in different distributions, and positions of central tendency measures in different distributions.

A conventional (high-density) print version of the lesson was initially prepared. Its style and basic content were patterned after the original text with minor modifications to make the presentation appropriate in length and difficulty for the present task. Total length was 18 pages and 2,123 words. Within each section the basic instructional orientation involved defining the concept or main idea and then illustrating its application with several context-based numerical examples.

In their research on summarizing text, Reder and Anderson (1980; 1982) were unable to find a published procedure for generating summaries which appeared sufficiently adaptable for representing complex text. Accordingly, they systematically generated summaries by (a) first defining a set of general rules for shortening the material, (b) having at least two people discuss the rules and rewrite the materials accordingly, and (c) reviewing the material and making changes until consensus was achieved that all criteria were satisfied. A similar orientation was followed in the present study. Specific rules employed were:

1. Reduce sentences to their main idea.

a. Remove any unnecessary modifiers, articles, or phrases.

b. Split complex sentences into single phrases.

2. Use outline form instead of paragraph form where appropriate.

3. Delete sentences that summarize or amplify without presenting new information.

4. Present information in "frames" containing limited amounts of new information, as in programmed instruction.

Although these rules were not sufficiently detailed to objectify all procedures, they could be easily applied by the two designers who drafted the lessons to yield comparable low-density formats. It was then a fairly simple matter to review the newly generated formats and reach agreement about final form. The completed low-density lesson consisted of 1,189 words, a 56% savings relative to the high-density version, and 15 pages, a 17% savings. These figures indicate slightly fewer pages for the low-density version (due in part to liberal use of white space) with a significant reduction in the average number of words per page. CBI versions of the high- and low-density lessons were prepared directly from the print materials. Word counts for corresponding low- and high-density versions were identical across print and computer modes. Due to the much smaller display area of the computer screen, it was not possible to duplicate the print page formats. Computer frames were thus designed independently, using what were subjectively decided to be the most appropriate screen layouts for presenting the material. Each screen provided both back- and forward-paging options. The final versions of the low- and high-density CBI lessons consisted of 49 and 66 frames, respectively. Figure 1 shows one of the high-density frames along with its parallel low-density version. It will be noted that the latter presents the same key information (definitional statement,

symbols, etc.) but with little elaboration or supporting context.

Insert Figure 1 about here

Attitude Survey

A 6-item attitude survey (print format) was administered at the completion of the lesson. Items consisted of statements about the learning experience to which subjects indicated levels of agreement or disagreement on a 5-point Likert-type scale (e.g., 1 = "strongly disagree," 5 = "strongly agree"). Abbreviated descriptions of the statements are: "Lesson moved quickly," "Material was interesting," "Was easy to learn," "Explanation was sufficient," "Text layout was easy to read," and "Prefer this method over lecture." Internal consistency reliability for the survey, computed by Cronbach's alpha formula, was r =.63 (n = 48).

Achievement Posttest

The achievement posttest (print format) consisted of four sections designed to assess different types of learning outcomes. The first two sections were considered knowledge subtests, since each assessed recognition or recall of information exactly as it appeared in the text. The knowledge-1 subtest ("definitions") contained 17 multiple-choice items, each consisting of a statement describing one, all, or none of the three central tendency measures (mean, mode, or median). Those that described central tendency measures included the exact key words contained in both low- and high-density narratives. Examples are: "It corresponds to the 50th percentile," "It is a central tendency measure," and "It is the average score." Two items that were nonexamples of central tendency both described the variance. The knowledge-2 subtest ("distributions")

contained eight questions concerning the effects of symmetrical and skewed distributions on the placement and interpretation of the mean and the median. On four of the items subjects were asked to write a brief rationale for their answers. The distributions shown on all items were exact replications of examples that appeared in the lesson.

The calculation subtest contained five problems requiring computation of different central tendency measures from new data not used in lesson examples. The transfer subtest consisted of 13 items that involved interpreting how central tendency would vary with changes in distributions or individual scores. Items of this type were not included in the lesson, nor were the underlying principles needed to answer those items explicitly stated. They were thus considered measures of transfer (or conceptual) learning. To illustrate, one of the transfer problem statements was as follows:

> On a history test, the class mean for 19 students is 65% correct, and the median is 65% correct. The mode, which is 60%, was obtained by 5 of the students. The highest grade was 95%. A test paper from the 20th student was mistakenly separated from the rest and was not considered in the statistical analysis. The teacher grades it and its score is 99%. How will its inclusion in the distribution affect the (a) median, (b) mean, and (c) mode? Provide a brief explanation of your answers.

Scoring rules on objective items and calculation problems awarded one point for a correct answer. On interpretative items one point was awarded for a correct answer and an additional point for a correct explanation. Internal consistency reliabilities were computed by means of the KR-20 formula for subtests with dichotomous item scores and by Cronbach's alpha formula for the remainder. A summary of resultant reliability values along with subtest lengths

and maximum points is as follows: knowledge-1 (17 items, 17 points, $\underline{r}$ =.60), knowledge-2 (8 items, 12 points, $\underline{r}$ =.57), calculation (5 items, 5 points, $\underline{r}$ =.67) and transfer (13 items, 20 points, $\underline{r}$ =.84).

Procedures

Subjects completed the profile data form during a regular class meeting, at which time they signed up to receive the learning task the following week. Typically from 3-15 subjects attended an individual session. Two similar classrooms were used, one for the print condition and the other for the CBI condition. The latter classroom contained 12 Apple IIe computers with monochrome screens, either single or double disk drives, and from 64K to 128K of memory. Proctors began the session with instructions for completing the task. All subjects then received a 2-page review unit entitled "Frequency Distributions," which covered prerequisite knowledge and special notation needed for the lesson. They were told that they could refer to the unit any time during the learning task.

Learning materials were then administered according to treatment. Instructions for all versions indicated that (a) five units would be presented on central tendency; (b) the units were to be studied at one's own pace; (c) turning back to reread preceding pages (frames) was permitted if desired; (d) since examples were completely worked out in the unit, time could be saved by examining rather than deriving solutions to longer problems; (e) it was permissible to ask the proctor any questions about the task procedure while learning; and (f) a posttest would be given following the learning task. Subjects in the learner-control treatment received additional instructions indicating that depending on how much explanation they desired, they could choose between "long" and "short" presentations on each unit. To help the subject make a decision for

the first unit, actual samples of parallel low- and high-density pages were shown. In the computer condition, subjects pressed a key to indicate their preferences, following which the appropriate high- or low-density version of the unit was presented. In the print condition, preferences were indicated orally to the proctor who then distributed appropriate materials. The same density selection procedures were repeated at the beginning of each of the remaining four sections. After subjects completed the last section, their finish tim es were recorded and the attitude survey was administered followed by the posttest.

Results

The basic statistical design was a 2(presentation mode) x 3(density condition) factorial. An alpha level of .Ø5 was used to judge significance. Treatment means and standard deviations on major dependent variables are summarized in Table 1.

Insert Table 1 about here

Initial 2 x 3 ANOVAs were conducted on responses to the profile data survey to judge the equivalence of treatment groups prior to the administration of experimental tasks. No significant main effects or interactions were found on any of the three items. Item responses suggested that the typical student viewed math as a "neutral" to "somewhat undesirable" subject, his/her math performance from "average" to "below average," and computers as slightly more preferable than textbooks for learning math.

Learner-Control Selections

Preliminary analyses were made of density-level selections by learner-control subjects. Results for CBI and print groups combined (n = 16)

showed that low-density and high-density materials were selected with equal frequency (both M's = 2.5) across the five sections. Low-density material, however, was selected an average of 3.75 times (and high density 1.25 times) by the print group, whereas the exact opposite pattern occurred for the CBI group (low density M = 1.25; high density M = 3.75). This difference was significant in a follow-up t-test for independent samples, $t(14) = 2.57$, $p < .05$. To determine the relationship between attitudes toward mathematics and density level selections, profile scores (Items 1 and 2 combined) were correlated with learner selections of low-density materials. The result $r = .14$ (df = 15) was in the predicted direction (more positive attitude = greater low-density preference), but was not significant.

Achievement Results

As previously described, the posttest was organized into four subtests labeled knowledge-1, knowledge-2, calculation, and transfer. Intercorrelations between subtest scores ranged from $r = .45$ (knowledge-2 and transfer) to $r = .66$ (calculation and transfer). Considering these only moderately high relationships and the distinct subtest differences in type of learning tested and question form used, it was decided to examine results on each separately.

Analysis of scores on the knowledge-1 subtest ("definitions") showed a significant main effect of presentation mode, $F(1, 42) = 4.48$, $p < .05$ (see ANOVA summary on Table 2). Subjects in the print condition (M = 13.1; 77% correct) scored higher than those in the CBI condition (M = 11.6; 68% correct). Neither the density level effect nor the interaction was significant.

Insert Table 2 about here

The ANOVA performed on calculation subtest scores, summarized in Table 3, showed the main effect of presentation mode, F (1, 47) = 10.08, $p < .02$, to be the only significant outcome. As on the knowledge-1 test, the print group (M = 4.0; 80% correct) surpassed the computer group (M = 3.1; 62% correct). No significant main or interaction effects were found on either the knowledge-2 or transfer subtests.

Insert Table 3 about here

In summary, posttest results favored the print group over the computer group in definitional knowledge and calculations. Density-level conditions did not differ from one another or interact with presentation mode on any subtest. There was a directional tendency, however, for higher performances to occur with low-density than high-density materials in the CBI condition but not in the print condition (see Table 1). Although that pattern is in the predicted direction, the effects are not sufficiently strong to indicate reliable trends.

Lesson Completion Time and Learning Efficiency

The analysis of lesson completion time yielded a highly significant presentation mode main effect, F (1, 42) = 26.65, $p < .001$; and a marginally significant density-level main effect, F (2, 42) = 2.53, $p < .10$. The mode x level interaction was not significant, F (2,42) = 1.83, $p > .05$. The presentation mode effect was due to print subjects' taking significantly less time (M = 18.0 min.) to complete the lesson than did CBI subjects (M = 32.3 min.). The ordering of density-level groups was as expected, with low-density lowest (M = 20.8 min.), learner-control next (M = 26.9 min.), and high-density

highest ($\underline{M}$ = 27.8 min.). The specific comparison between high- and low-density levels is attentuated, however, by the inclusion of the learner-control treatment which represented a mixture of the two variations. When the learner-control treatment was excluded from the analysis, the time difference between high- and low-density groups reached significance, $\underline{F}$ (1, 427) = 4.30, $\underline{p} < .05$.

In interpreting the relatively long CBI completion times, one may question to what extent operational requirements (pressing keys, waiting for prompts and displays) and the greater page length of the CBI lesson artificially extended time on task. To correct for this possible bias, we estimated the amount of time required merely to "page through" the complete low- and high-density CBI lessons, without attempting to read any display. Averaged across several trials, mean "administration" times were determined to be 6.45 min. and 4.45 min for the high- and low-density lessons respectively. Adjusted CBI completion times were then computed for high- and low-density groups by subtracting the respective constant from total completion times. Because many learner-control subjects varied their selection of density levels across lesson sections, neither correction figure would be exactly accurate for these individuals. Rather than derive individualized figures, it seemed sufficient for present purposes to use the more conservative high-density adjustment for all learner-control subjects. The adjusted time results corroborated original time results by showing the instructional mode main effect to be significant, $\underline{F}$ (1, 42) = 13.03, $\underline{p} < .001$. The adjusted CBI mean was 28.0 min. compared to the original print mean of 18.0. This effect was sufficiently strong to suggest factors other than administration delays to account for CBI subjects' slower pacing.

A desired outcome of adaptive instructional strategies is to improve learning efficiency, as measured by the level of achievement attained per

instructional time allocated. Accordingly, as in several previous studies on adaptive instruction (Ross & Rakow, 1981; Tennyson & Rothen, 1977), treatments were compared on efficiency scores, computed as the ratio of posttest total score divided by lesson completion time. Separate efficiency scores, using both total time scores and adjusted time scores, were computed for CBI subjects. The ANOVA results were the same for both measures, indicating the instructional mode main effect to be the only significant source of variance ($p < .05$) in each analysis. Efficiency means for these comparisons were 2.15 for print versus 1.21 for CBI-total time and 1.46 for CBI-adjusted time.

Attitude Results

The analysis of attitude total (6-item) score yielded no significant main or interaction effects. Given that each attitude item dealt with a different property of the lesson, follow-up analyses were conducted to examine separate outcomes on each. No effects were obtained on Items 2 ("interesting"), 3 ("easy to learn"), and 5 ("readable layout"). On Item 1 ("lesson moved quickly"), the presentation mode x density level interaction was significant, F (1, 42) = 5.15, $p < .05$; and the presentation mode main effect approached significance ($p < .10$). Follow-up analyses, using the Tukey HSD procedure, consisted of comparing CBI and print means within each of the three density-level variations. The only difference was found within the high-density condition, showing that print subjects ($M = 4.25$) gave significantly higher ratings ($p < .05$) than CBI subjects ($M = 2.50$). Thus, although there was an overall tendency for print subjects to perceive the lesson as faster moving than did CBI subjects ($M's$ = 3.71 and 3.17 respectively), this differential was especially pronounced when high-density material was used.

On Item 4 ("amount of explanation was sufficient") the two-way interaction

was again significant, $F(2, 42) = 4.22$, $p < .05$. Comparisons between presentation modes showed significant variation only within the low-density condition: CBI subjects ($M = 4.50$) rated the materials higher ($p < .05$) in sufficiency than did print subjects ($M = 3.23$). The only other significant finding was the presentation mode main effect on Item 6 ("prefer method over lecture"), $F(1, 42) = 5.28$, $p < .05$. CBI subjects ($M = 3.75$) were more positive about the teaching method received than were print subjects ($M = 2.96$).

Discussion

Similar to Reder & Anderson's (1980; 1982) findings with college textbooks, the present results showed that, with both CBI and print materials, low-density text was as effective for learning as high-density text. As expected, however, the high-density lesson took more time to complete (a 33% increase) than the low-density version. Comparisons between presentation modes showed advantages for print over CBI in achievement, completion time, and learning efficiency. Interpretations of the findings follow.

Density Level Effects

In contrast to Reder and Anderson's (1980; 1982) subjects who were tested exclusively on factual recognition (via true-false questions), the present sample was administered a variety of achievement measures designed to assess factual knowledge, problem solving, and transfer. The absence of any evidence favoring the high-density text is consistent with the view, as theorized in hierarchical models of text structure (Meyer, 1975), that retrieval of main ideas is not facilitated by providing additional details (or elaborations) in the text. Main ideas support the recall of details, not the reverse. On relatively simple types of tasks, low-density text also has the intrinsic advantage of providing only the essential information needed to learn task-relevant skills. These

interpretations are not intended to discourage typical uses of traditional (high-density) text narrative in learning materials. If students are to develop good reading and writing skills, frequent exposure to elaborated and structurally sophisticated text styles (as opposed to outlines, summaries, or listings) seems essential. Recent findings by Reder et al (1986) further suggest that elaborated text is advantageous for learning complex procedural skills, such as how to operate a computer, seemingly as a result of providing very specific guidance for implementing the procedure. With these qualifications in mind, instructional designers might consider the following heuristic (Romiszowski, 1981) suggested by this study: Where it is difficult or costly to display long segments of narrative text, as is usually the case in CBI, use of low-density narrative can reduce lesson length and completion time, without decreasing task-relevant learning. The procedures described here and by Reder and Anderson (1980-1982) for creating low-density materials from conventional text seem both valid and practical for that purpose.

Presentation Mode Effects

Overall, the experimental findings were not supportive of CBI relative to print as a delivery medium for the present statistics lesson. On both the knowledge-1 (definitions) and calculation subtests the print group scored significantly higher than the CBI group (see Table 1). Although transfer scores were relatively low for both groups, the print group ($\underline{M}$ =59%) was directionally superior to the CBI group ($\underline{M}$ =49%). Print was also directionally higher on the knowledge-2 subtest, but the difference was smaller than on other subtests. A contributing factor may have been the emphasis of the associated lesson content on interpreting graphs and tables, which resulted in print pages and screen displays being much closer in appearance than in other sections. Other results

were significantly longer completion times and lower learning efficiency under CBI than under print. Specifically, CBI subjects averaged 79% more total time and 78% lower efficiency than print subjects.

These negative results for CBI contrast with findings of superior achievement and faster completion times in other studies using CBI for mathematics instruction (see Burns & Bozeman, 1983; Kulik, Bangert, & Williams, 1983; Kulik, Kulik, & Cohen, 1980; Ragosta, Holland, & Jameson, 1984). In attempting to reconcile this apparent inconsistency one might consider Clark's (1983) suggestion that it is not media per se that affect learning, but the instructional strategies that the given media employ (also see Clark, 1984; 1985; Solomon & Gardner, 1985). Clark (1983) reinforces this point through the following analogy, "media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 45). From this perspective, the consistency of outcomes across media studies would seem more validly interpreted on the basis of the instructional strategies used and the content taught rather than on how the lesson was delivered. It thus becomes important to recognize the present lesson's dependency on mostly narrative descriptions of rules and operations and allowance of self-pacing. These instructional features remained constant regardless of mode, but print offered the possible advantage of representing the text in a more readable and accessible form. Had the lesson been designed to capitalize on special computer capabilities such as interactive responding or personalized examples and feedback (Anand & Ross, in press; Bork, 1985), outcomes of the treatment comparison may have been quite different.

Separate from media and content attributes are learner characteristics. Most subjects in the present study were unfamiliar with and probably somewhat

threatened by both the statistical subject matter and learning from CBI. According to Salomon (1981; 1983; 1984), how students feel about the difficulty of the presentation medium influences their persistence on the task. Children, for example, have been found to view television as an "easy" medium and consequently to reduce the amount of effort they expend in processing its content (Salomon, 1985). Given the newness of CBI for the present sample and its reputation as a "smart" medium (see Clark, 1984; Salomon & Gardner, 1986), it would seem likely that many subjects would naturally perceive it as more difficult or challenging than print. Such perceptions, if they occurred, would be consistent with the high degree of task persistence demonstrated by CBI subjects in their very deliberate pacing rates and preferences for high-density over low-density material under learner control.

Attitude results also suggested differences in how the two media were perceived. Subjects' generally favorable reactions to CBI were conveyed in their giving it higher ratings than print as a desired alternative to lecture. Interestingly, neither mode was favored on "clarity" or "readability" dimensions, but CBI subjects rated the lesson as slower moving than did print subjects, especially when high density material was used. CBI subjects also rated low-density material higher in sufficiency than did print subjects, even though both groups received the exact same content. Simply put, "less" was perceived as "more" when CBI was used. Despite these perceptions, learner-control selections by the CBI group favored high density materials 75% of the time, compared to only a 25% selection rate under print. The overall impression is of a less confident and more conservative attitude of the CBI group, which generally worked as a disadvantage for achievement and learning efficiency.

Based on the above interpretations we would suggest the following

modification of Clark's (1983) analogy between media and delivery trucks. Depending on the circumstances, it does seem that the type of delivery truck driven could adversely affect our nutritional health, if it lacked the attributes required (e.g., a refrigeration unit) to deliver the types of products carried in good condition and on time. The critical challenge for instructional designers is to systematically integrate delivery methods (media) and products (instructional material) to yield the most effective combination given the special attributes of each, task objectives, and student characteristics.

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Table 1

Treatment Means and Standard Deviations on Major Dependent Measures

Measure	Print				Computer			
	L-Density	H-Density	L-Control	All	L-Density	H-Density	L-Control	All
Knowledge-1 (17)[a]								
M	12.6	13.1	13.6	13.1	12.1	11.0	11.6	11.6
SD	1.8	1.5	2.0	1.8	3.4	3.0	2.8	3.0
Knowledge-2 (4)								
M	7.4	7.3	9.0	7.9	8.1	7.1	7.5	7.6
SD	2.7	4.5	2.9	3.4	3.2	3.3	3.2	3.1
Calculation (5)								
M	3.8	3.8	4.5	4.0	3.6	2.4	3.3	3.1
SD	0.9	1.5	0.8	1.1	1.5	1.7	1.3	1.5
Transfer (20)								
M	10.6	10.9	14.3	11.9	10.5	9.1	9.8	9.8
SD	5.7	4.3	3.9	4.8	6.4	7.3	5.1	6.1
Attitude Total (30)								
M	20.0	21.7	21.5	21.1	21.6	20.6	21.9	21.4
SD	4.9	4.3	3.0	4.0	2.9	2.8	2.7	2.8
Study Time (Min.)								
M	17.4	18.4	18.4	18.0	24.3	37.3	35.5	32.3
SD	3.7	3.1	3.8	3.4	8.4	16.4	13.1	13.8

[a]Numbers in parentheses following measures indicate maximum scores.

Table 2

Summary of ANOVA Results and Knowledge-1 Subtest

Source	Mean Square	df	F
Mode (M)	28.52	1	4.48*
Density Level (D)	.27	2	.20
M x D	3.27	2	.51
Error	6.37	42	

*p < .05

Table 3

Summary of ANOVA Results on Calculation Subtest

Source	Mean Square	df	F
Mode (M)	10.08	1	5.86*
Density Level (D)	2.90	2	1.68
M x D	1.90	2	1.10
Error	1.72	42	

*p < .05

Figure Caption

Figure 1. Sample low-density and high-density frames from CBI lesson.

Low-density sample

CENTRAL TENDENCY

A summary of group achievement is the score most typical or representative of all scores in a frequency distribution

These scores are measures of central tendency

Three common central tendency measures:

Mode--most frequently occurring

Median--middle score

Mean--the "average"

B< Press any key to continue >F

High-density sample

CENTRAL TENDENCY

A good way to precisely summarize group achievement would be to determine the score that is most typical or representative of all scores in a frequency distribution. We call these typical or representative scores measures of central tendency.

A measure of central tendency is a score that is typical or representative of a group of scores. Three of the most commonly employed central tendency measures are the mode (most frequently occurring score), the median (the middle score), and the mean (the "average" score). Most importantly though--any measure of central tendency is supposed to indicate a "representative" score value for the group being evaluated.

B< Press any key to continue >F